Assuring Advanced Small Arms System Value Utilizing Cost As An Independent Variable (CAIV)

14 August 2001

ATK
ALLIANT TECHSYSTEMS

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
14Aug2001	N/A	-

Title and Subtitle Assuring Advanced Small Arms System Value Utilizing Cost As An Independent Variable (CAIV) Assuring Advanced Small Arms System Value Utilizing Cost As An Independent Variable (CAIV)	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Broden, Dave; Giles, Pete	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) ATK Weapon Systems Technical Director	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) NDIA (National Defense Industrial Association) 211 Wilson Blvd, STE. 400 Arlington, VA 22201-3061	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes Proceedings from the 2001 Joint Services Small Arms Symposium, Exhibition & Firing Demonstration 13-16 August 2001 Sponsored by NDIA	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 33	

Presenters

Dave Broden
ATK
Weapon Systems
Technical Director

Pete Gilles
ATK
System Analyst

Objectives

Overview CAIV Application for Small Arms System Definition and Manufacturing Decisions

- Programmatic
- Technical
- Manufacturing
- Affordability

Effective and Timely CAIV Application Benefits System Life Cycle Management

What Does CAIV Address?

Are Requirements Defined Clearly?

Do Requirements Add Value?

- Operational
- Survivability
- Maintenance

Can Requirement Be Achieved By Other Means?

- Hardware vs. training
- Level of maintenance

Integration vs. Modularity Value?

- What is value of integration?
  - Complexity
  - Utility

Is Technology Ready? Does It Meet Objectives? When?

- Performance
- Design

Identifies Affordability Drivers

- Manufacturing
- Schedule

CAIV

Legacy and Emerging Small Arms System Enhancements

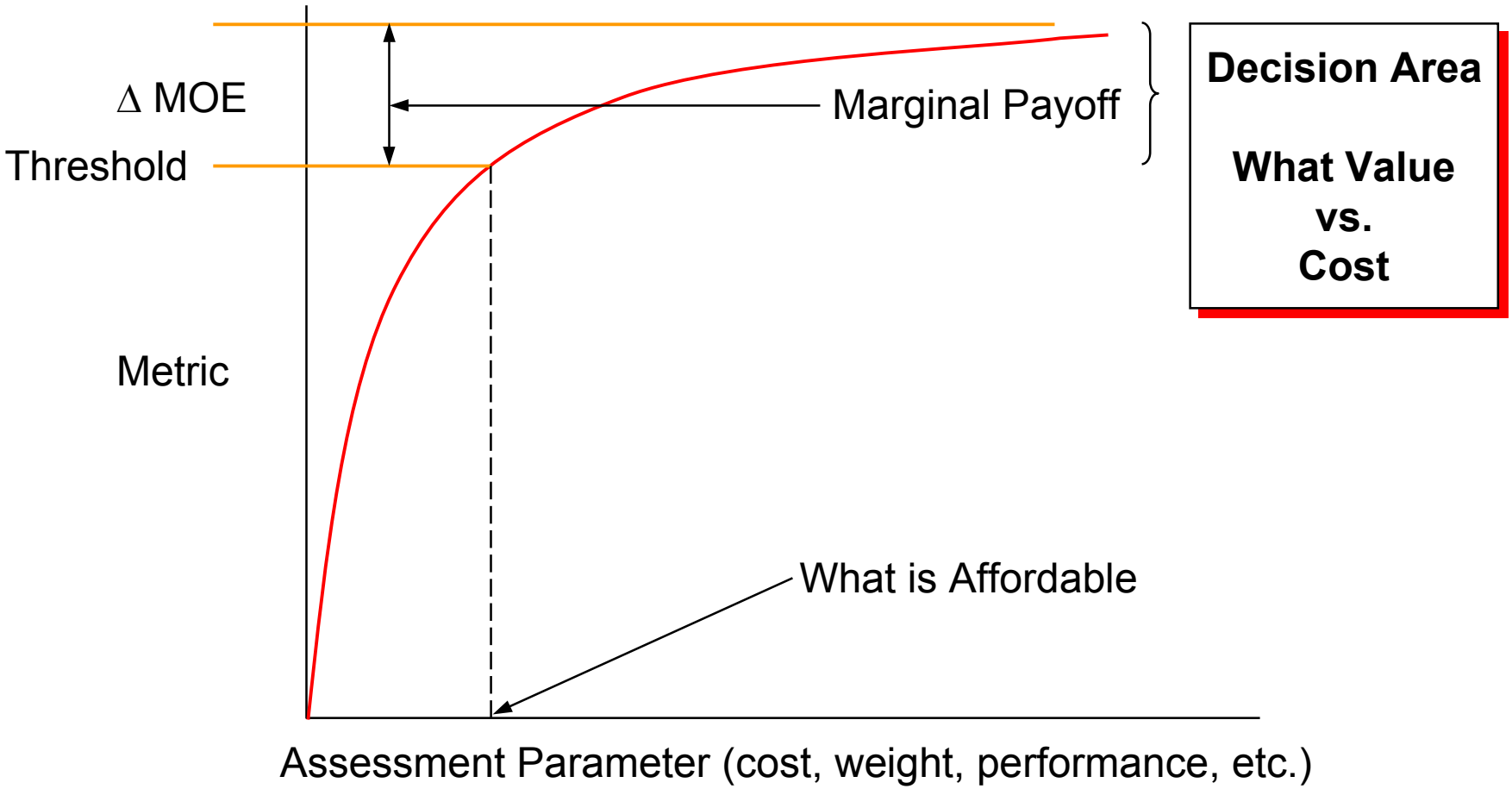
- System design
- Performance enhancements
  - Baseline
  - Pre-planned
- Modularity functions
- Training
- Requirements validation

Decision process for user benefits/utility and affordability

- **Technology offers opportunity**
- **Transformation requires response**

CAIV Application = Value Decision

CAIV Overview



Earning "Best Value" — Establishing Marginal Payoff

Why Utilize CAIV?

- Performance
- Affordability
- Schedule
- Risk
- Maintenance
- Upgrades/technology insertion

Effective Use of CAIV Provides "User Value" — Facilitates Fielding — Provides Basis for Incremental Growth

Small Arms CAIV Applications

- OICW
- OCSW
- Legacy System Upgrades
- MOD Weapon System
- Bursting Munition System Integration
- Small Arms System Training
- Supportability Approaches
- Manufacturing Commonality
- Interoperability

Decisions		**Payoff**
– Performance		– Operational
– Schedule	vs.	– Logistics
– Cost		– TOC

CAIV

OICW Applications

- System architecture
- P(I) value assessment
- Weight
- Functionality
- Supportability
- Training
- Land Warrior interface

Determining

- Operational Requirements Documents (ORD) compliance
- Unit Production Cost (UPC)
- Total Ownership Cost (TOC)

Ensuring:
- Operational utility
- Affordability

Superior 21st Century Soldier Effectiveness

CAIV Examples

- Integration vs. modularity
- Operational life with power source (type, technology, design)
- Functional levels and options
- Performance level vs. technology cost
- Design/performance vs. manufacturing cost
- Reliability advantage/cost vs. maintenance
- Hardware integration vs. training
- Product maturity vs. obsolescence

Select Priority Areas for CAIV Emphasis

Establish Measurable Metrics and Criteria

CAIV Metrics

Objective: Measure of Effectiveness/Metric (MOEs) which characterize the design/performance

Example:
- P(I)
- P(CL)
- Power consumption
- Power capability
- Weight
- Ruggedness
- Functionality

Approach: Threshold and Objectives MOEs
- Evolving thresholds tied to milestones
- Objective (challenge level)
  - Measure similar parameters
  - Level requires major improvements, technology breakthrough, etc.

Measurable: Must be defined to be quantified
- Test
- Analysis
- Cost

CAIV MOE Example

MOE (1) Operational scenario assessment

- Number of rounds
- Exchange ratio

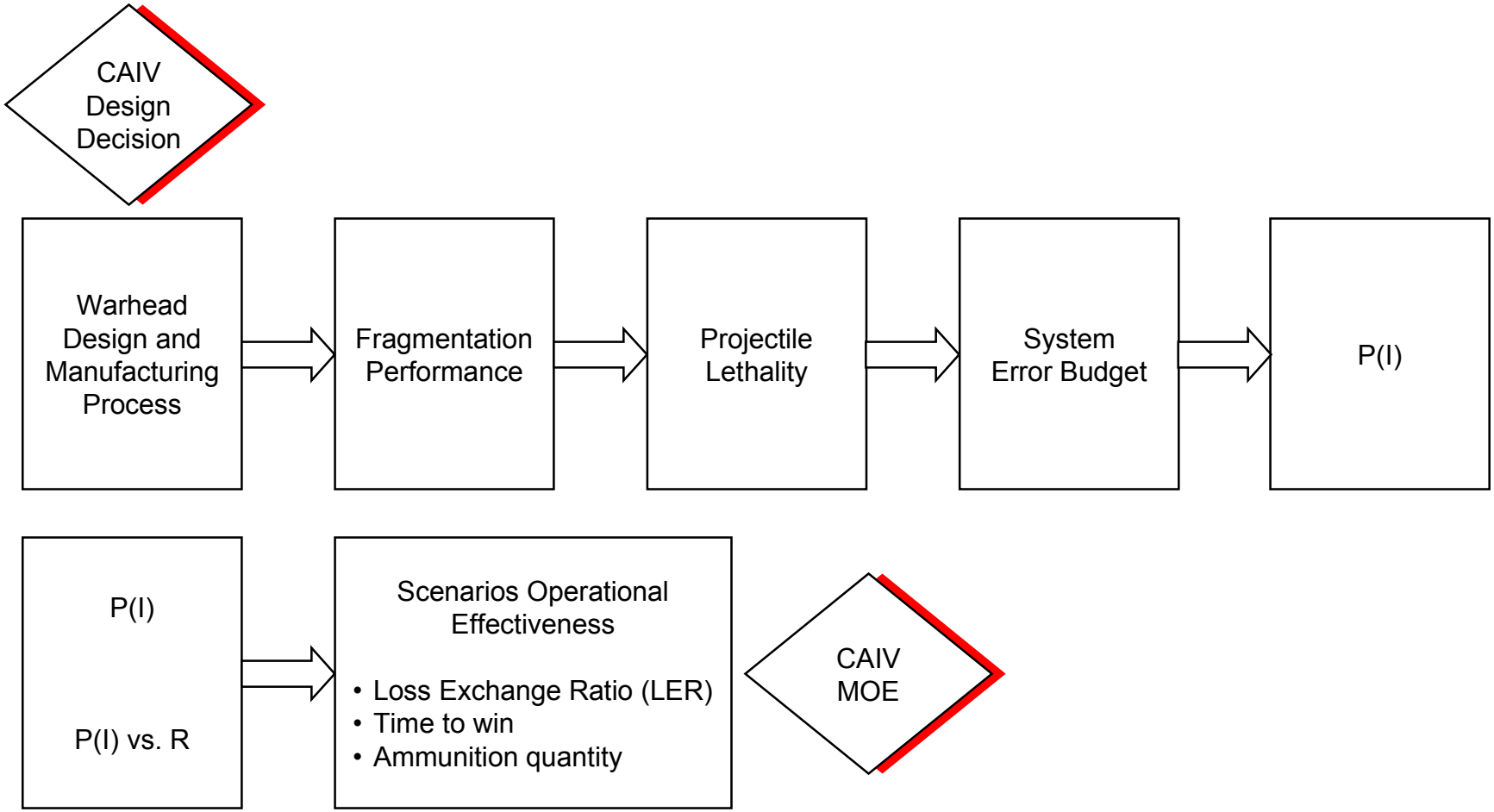
MOE (2) P(I) = Probability of incapacitation
= f [(error budget)] [f(fuze parameters)] [f(warhead parameters)]
= determined in terms of P(I) level [(e.g.) P(I) = 0.5 vs. 0.3]
P(I) at range [e.g., R = 500 vs. 300]

CAIV Questions

1. What is operational payoff?
2. What is the cost to reach P(I) objective?
3. Address warhead parameters
   – Caliber
   – Warhead material
   – Error budget

- **What are associated costs?**
- **How does change affect outcome?**

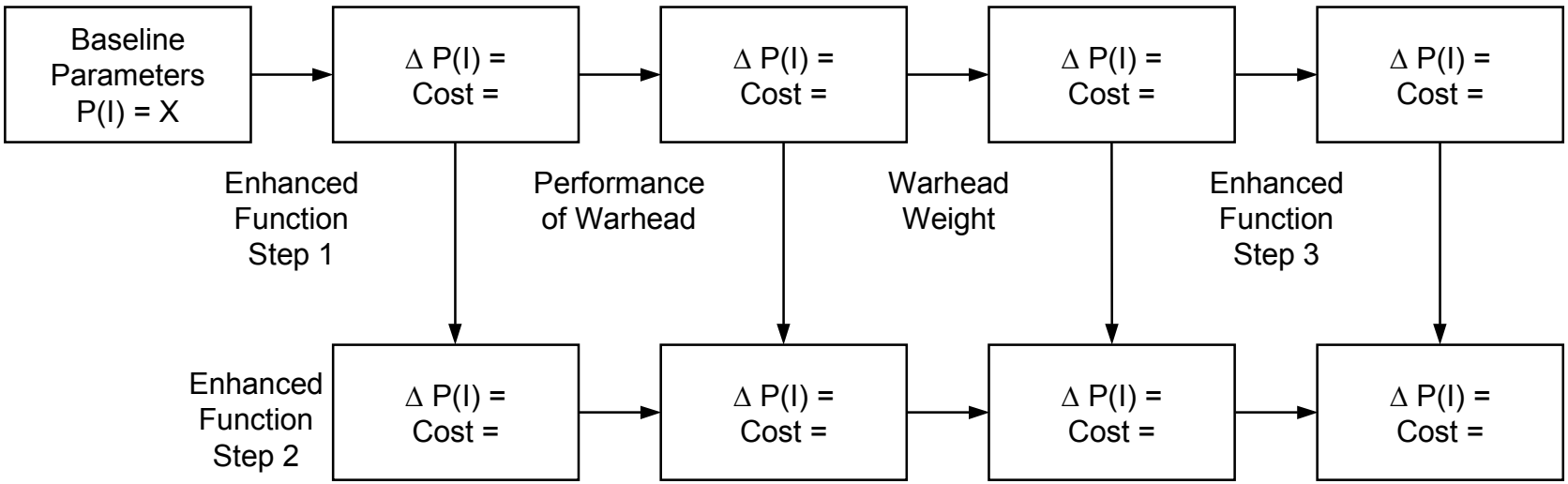
CAIV MOE Selection



Relating CAIV MOEs to Design Parameters Realizes the Benefit

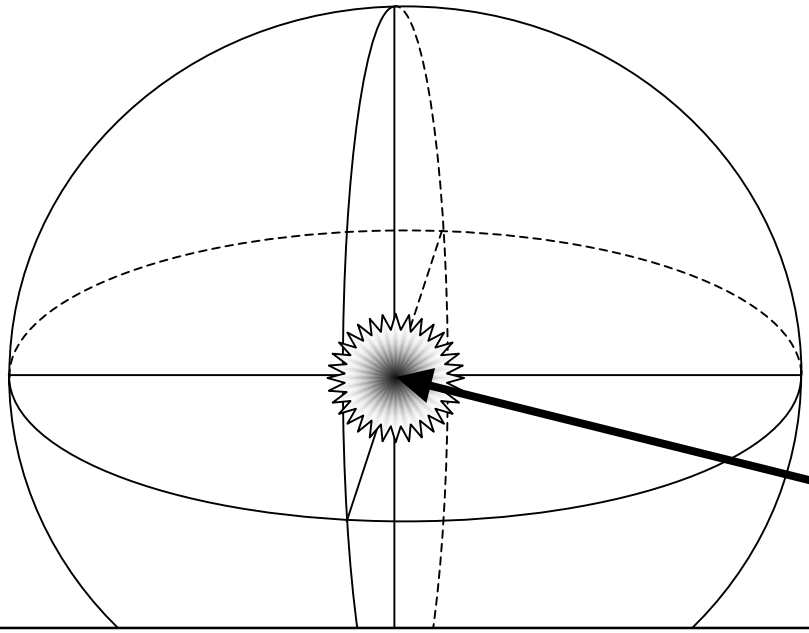
CAIV Roadmap

Establish Value of Incremental Changes

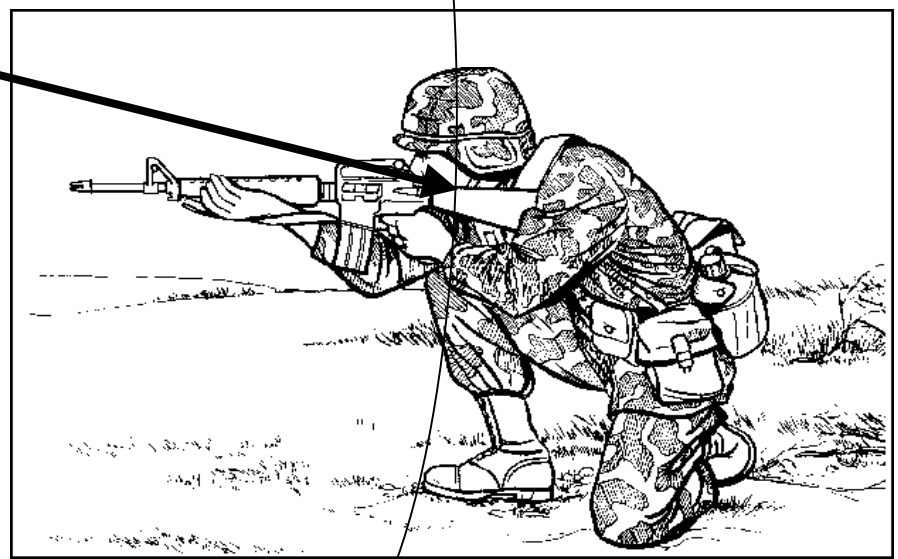


Evolving Best Value in Requirement and Design

Bursting Munition Lethality



Steradians subtended by target decreases with distance from burst point to target



Fragment density measured in fragments per Steradian remains constant for given weapon detonation

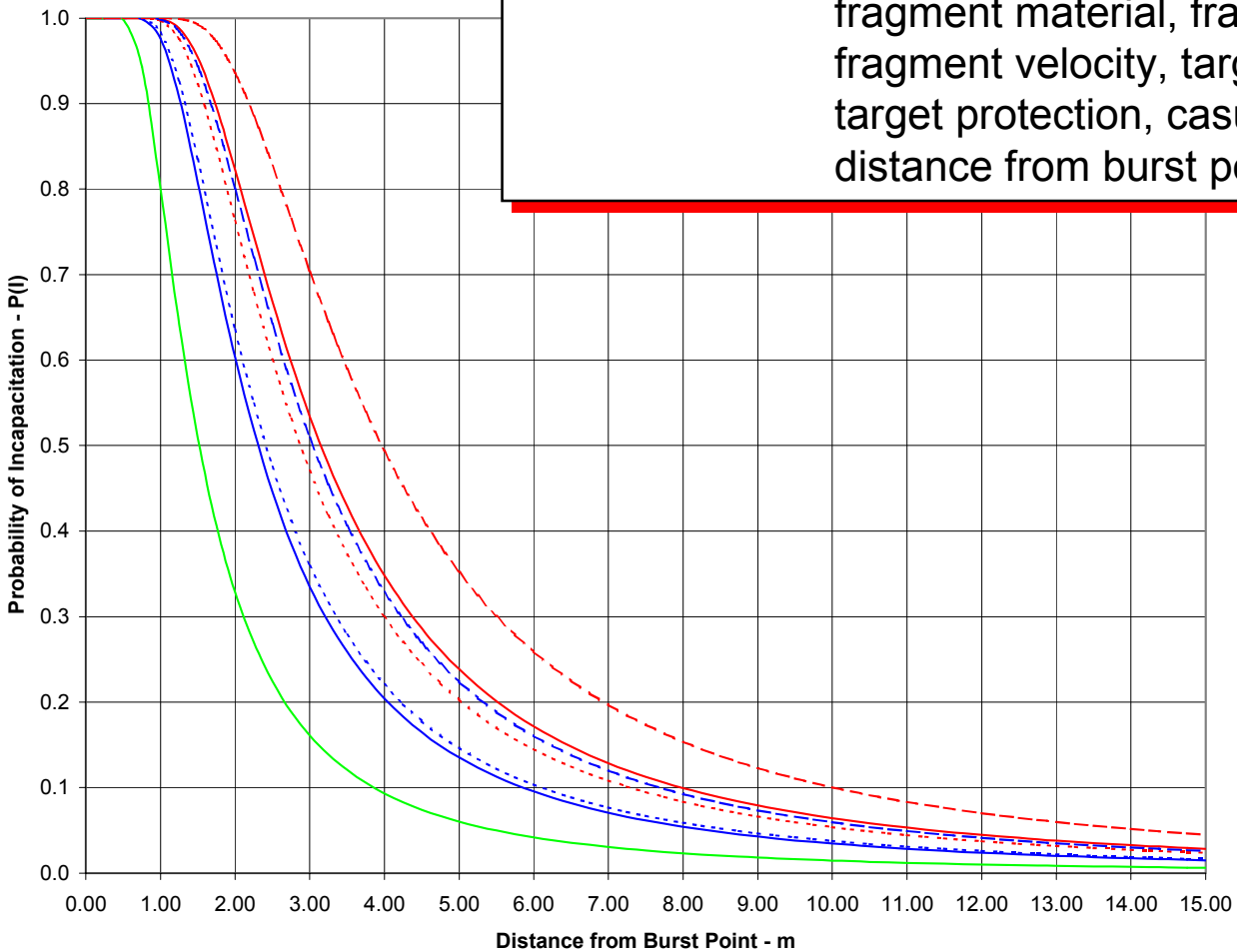
Example:

600 fragments / 4π = 47.74 fragments per Steradian

ATK
ALLIANT TECHSYSTEMS

Warhead Lethality Measure of Effectiveness

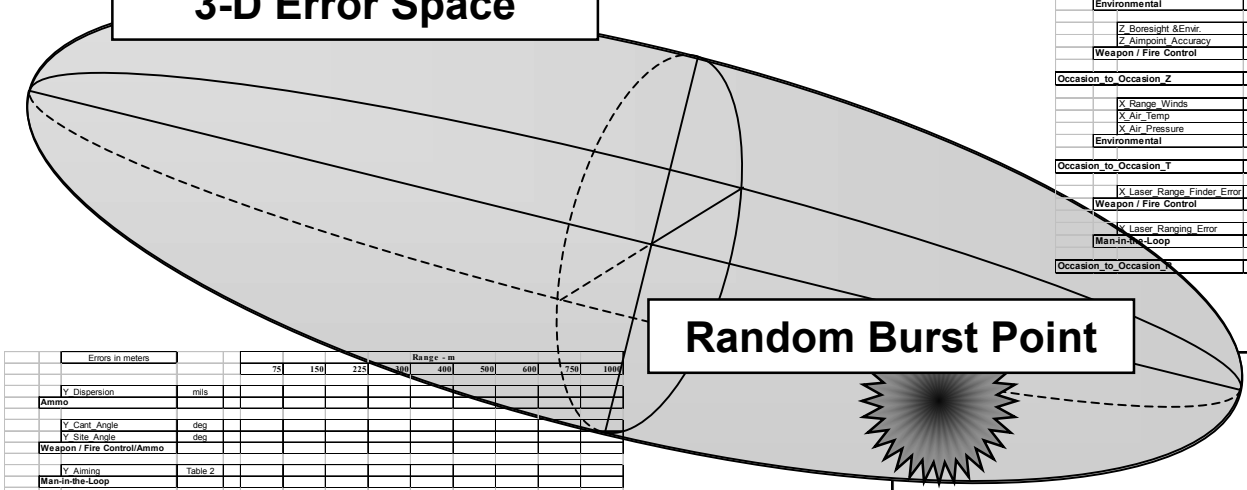
Incapacitation = Fnc (number of fragments, fragment material, fragment mass, fragment velocity, target posture, target protection, casualty criteria, distance from burst point)



Bursting Munition Error Budget

Small Arms
NDIA
2001

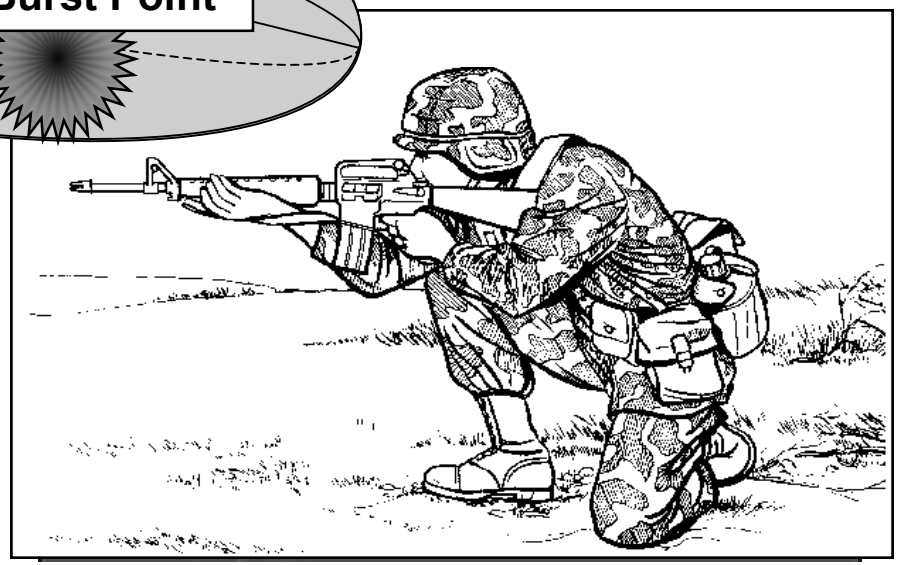
3-D Error Space



Occasion to Occasion Errors

	Errors in meters		Range - m								
			75	150	225	300	400	500	600	750	1000
	Y_Cross_Winds	mps									
Environmental											
	Y_Boresight & Wind	mils									
	Y_Aimpoint_Accuracy	Table									
Weapon / Fire Control			0	0	0	0	0	0	0	0	0
Occasion_to_Occasion_H	OOX		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Z_Range_Winds	mps									
	Z_Air_Temp	deg									
	Z_Air_Pressure	mbar									
Environmental											
	Z_Boresight &Envir.	mils									
	Z_Aimpoint_Accuracy	Table									
Weapon / Fire Control											
Occasion_to_Occasion_Z	OOZ										
	X_Range_Winds	mps									
	X_Air_Temp	deg									
	X_Air_Pressure	mbar									
Environmental											
Occasion_to_Occasion_T	OOT		0	0	0	0	0	0	0	0	0
	X_Laser_Range_Finder_Error										
Weapon / Fire Control											
	K_Laser_Ranging_Error	0.00%									
Man-in-the-Loop											
Occasion_to_Occasion_R	REE		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Random Burst Point

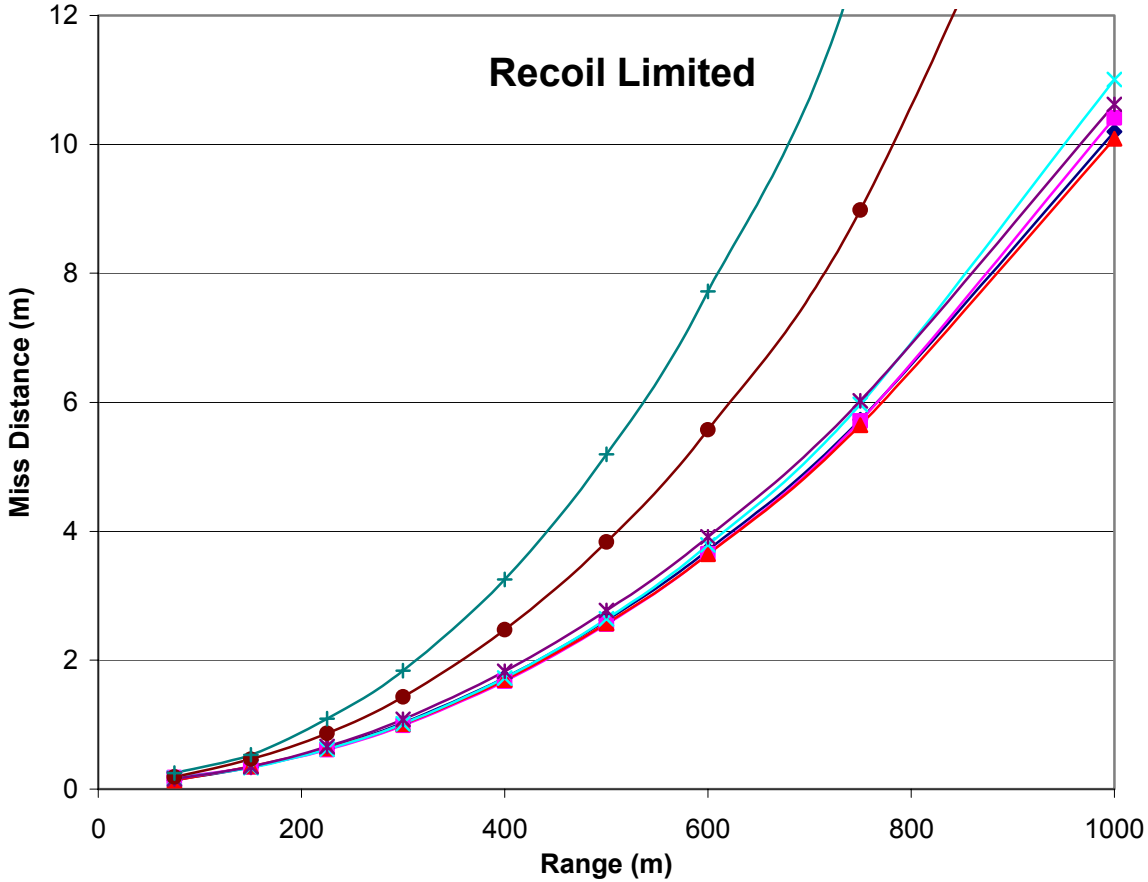


Random Errors

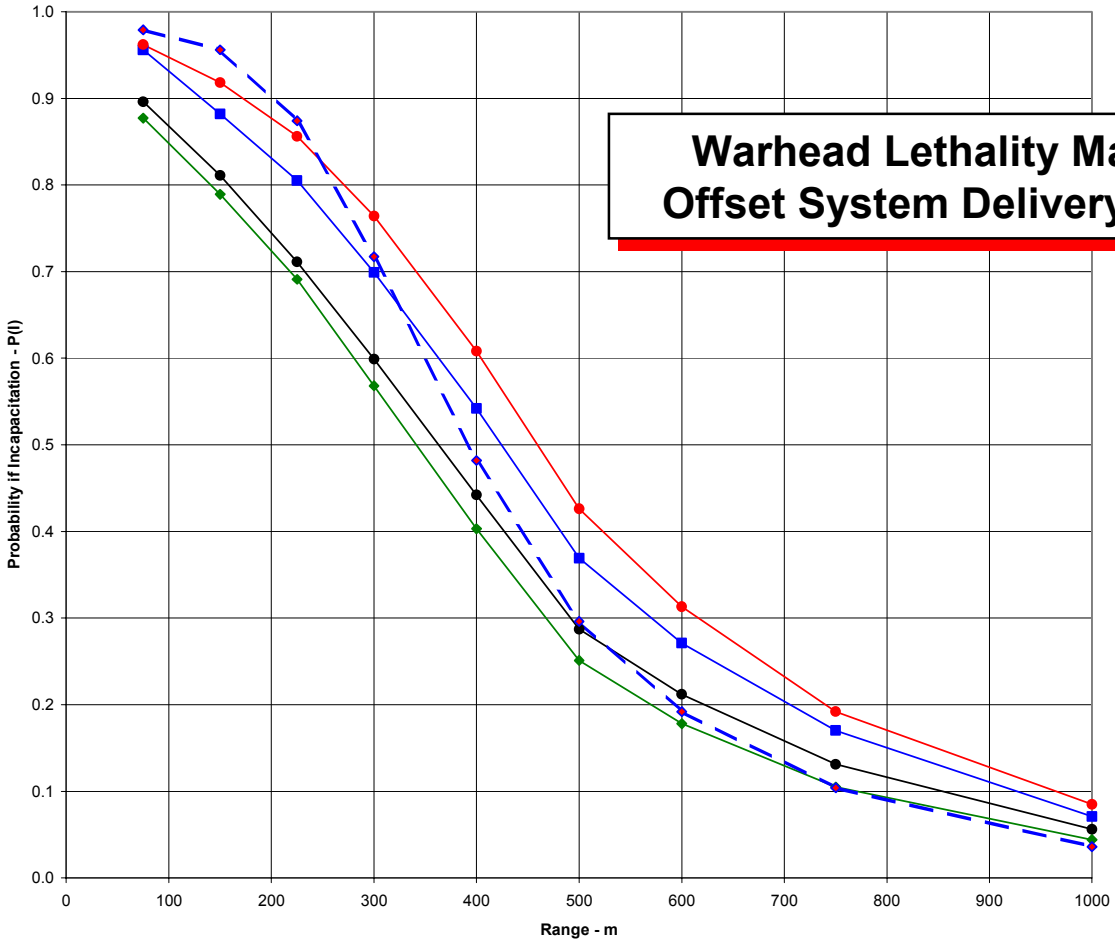
	Errors in meters		Range - m								
			75	150	225	300	400	500	600	750	1000
	Y_Dispersion	mils									
Ammo											
	Y_Cant_Angle	deg									
	Y_Site_Angle	deg									
Weapon / Fire Control/Ammo											
	Y_Aiming	Table 2									
Man-in-the-Loop											
Random_H	WBX		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Muzzle_Velocity	m/s									
	Drag_Variability	%									
	Twist	deg									
	Spin_Damping	%									
	mass, lxx	gm									
	$C_{M\alpha}, C_{M\dot{\alpha}}$	%									
	d_ref	mm									
	Z_Dispersion	mils									
Ammo											
	Z_Cant_Angle	deg									
	Z_Site_Angle	deg									
Weapon / Fire Control/Ammo											
	Z_Aiming	Table 2									
Man-in-the-Loop											
Random_Z	WBZ		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Muzzle_Velocity	m/s									
	Drag_Variability	%									
	Twist	deg									
	Spin_Damping	%									
	mass, lxx	gm									
	Turns Count Accuracy	%									
	d_ref	mm									
Ammo											
	Site_Angle	deg									
Weapon / Fire Control/Ammo											
Random_T	WBT		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total_T	TSD		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

ATK
ALLIANT TECHSYSTEMS

System Performance – Miss Distance



System Performance
Probability of Incapacitation



Warhead Lethality May Not Offset System Delivery Errors

ATK
ALLIANT TECHSYSTEMS

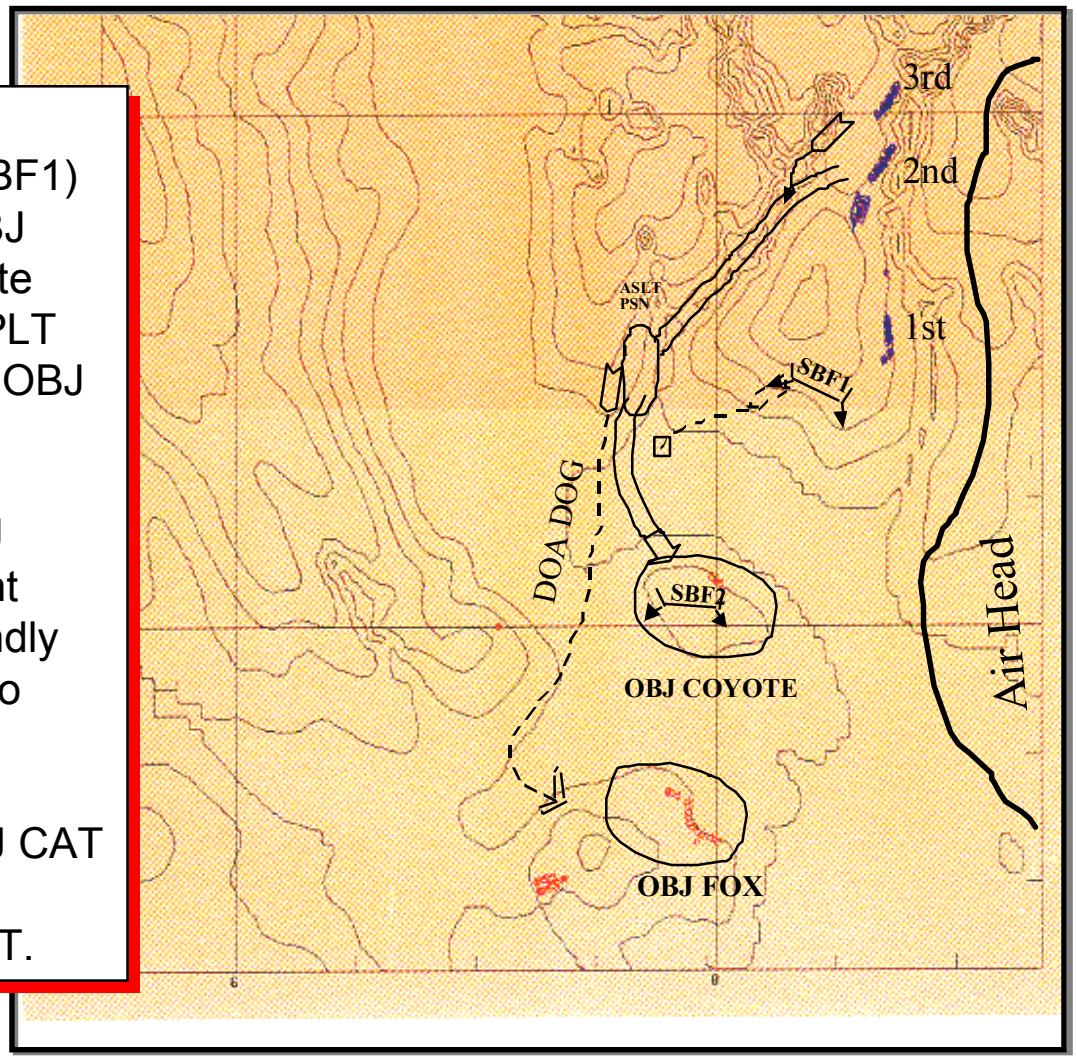
System Performance
CASTFOREM Force on Force Scenario

HRV 49A Concept of the Operation

1. 1st PLT establish support by fire 1(SBF1) to fix enemy vic OBJ COYOTE to facilitate movement of 2nd PLT and on order seize OBJ FOX.

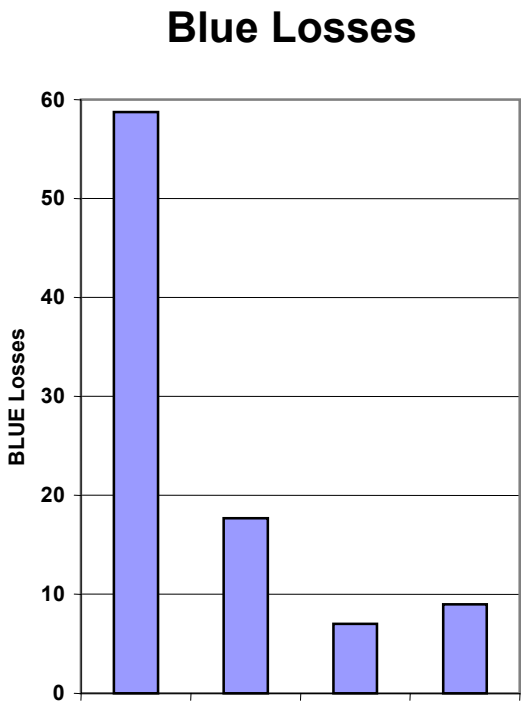
2. 2nd PLT seize OBJ COYOTE to prevent interference of friendly forces' movement to OBJ FOX.

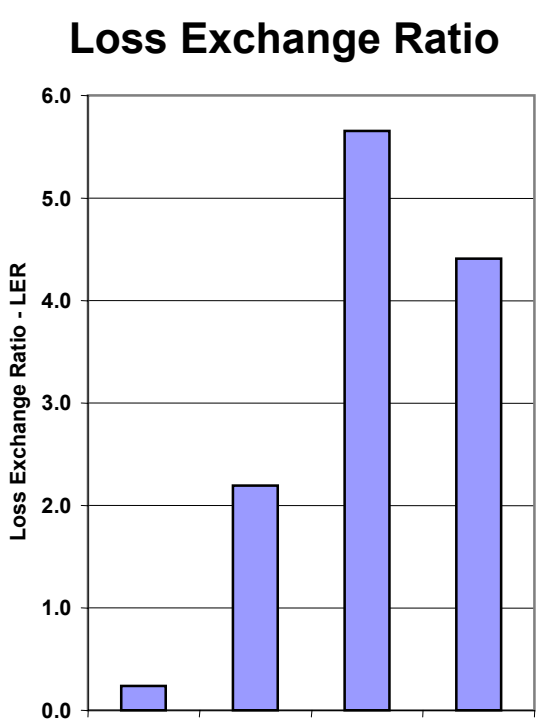
3. 3rd PLT seize OBJ CAT to facilitate 1st PLT assault on OBJ RAT.

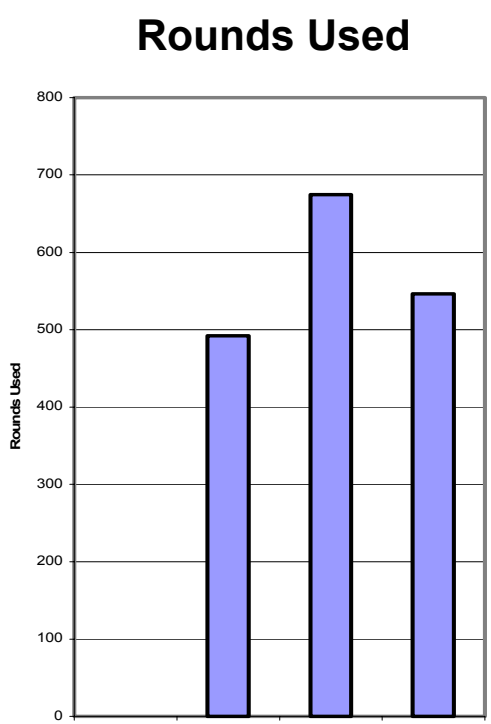


System Performance
Force on Force Measures of Effectiveness

- Loss Exchange Ratio (LER) is not always the most significant metric
- Logistics costs (dollars and pallets) are decision drivers







CAIV Issues

- Which projectile maximizes operational MOE?
  - P(I) level appropriate?
  - P(I) range appropriate?
- Which projectile is lowest cost?
- Is projectile cost increase offset with reduced logistics cost?
- Which approach minimizes schedule risk?

Linking Performance, Design, Manufacturing, and Supportability to Realize Schedule, Operational, and Affordability Advantages

CAIV Databases

Operational MOEs		Number of rounds
• Established by system effectiveness		Range P(I) sensitivity
Design/Performance		
• Established from	Fragmentation tests	P(I)
	Analysis	
	Manufacturing	UPC
Logistics		
• Established from supportability assessments		TOC TOC sensitivity
Schedule		Schedule
• Established by	Risk assessment	UPC
	Manufacturing planning	TOC

MOEs and Costs Can Be Quantified and Tracked

CAIV Assessment Parameters

Systems

1. System Integration vs. Modularity
2. Logistics/Maintenance Level
3. Weight vs. Schedule/Cost to Achieve Weight
5. P(I) Level
6. Range
7. Ruggedness

Weapon

1. Housing Material/Process
2. Barrel Material(s)
3. Harness/Connectors

TA/FCS

1. Sensor Performance
   - DVO
   - Video
   - Thermal
2. ASIC vs. COTS Processor
3. Laser Range Finder
   - Performance
   - Weight
4. Tracker/Laser Steering Integration
5. Alternatives to Maximize P(CL)
6. Power Management (Power Source vs. Life)
7. CIDDS
8. Training Module
9. Sensor Fusion

Ammunition & Fuze

1. HE Ammunition
   - Warhead Material
   - Warhead Fabrication
2. KE Ammunition
   - 5.5.6mm
   - Other
3. Fuze
   - ASIC vs. COTS
   - Fuze size vs. cost
   - Power source

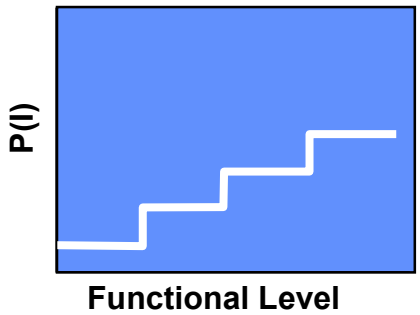
Training

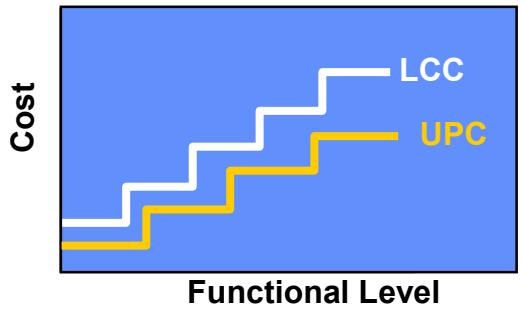
1. Simulator Types
2. Training Rounds
   - TPS
   - Blank

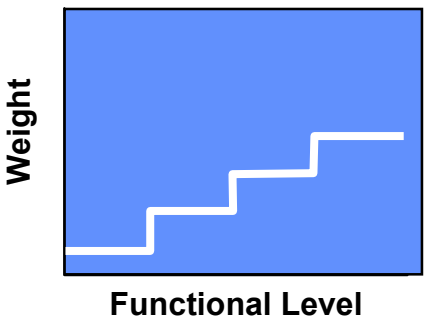
CAIV Process Implementation Supports Design Process

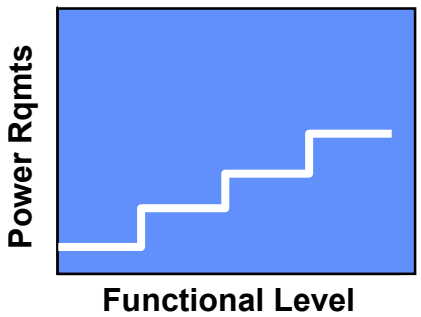
System Functional Level Assessment

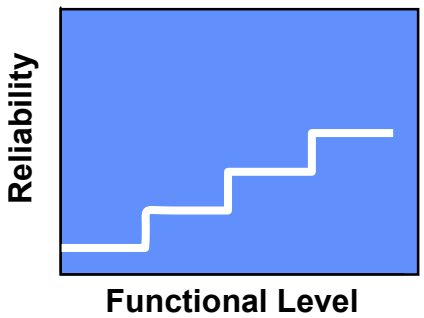
(Examples Only)











CAIV Link Functional Levels

CAIV

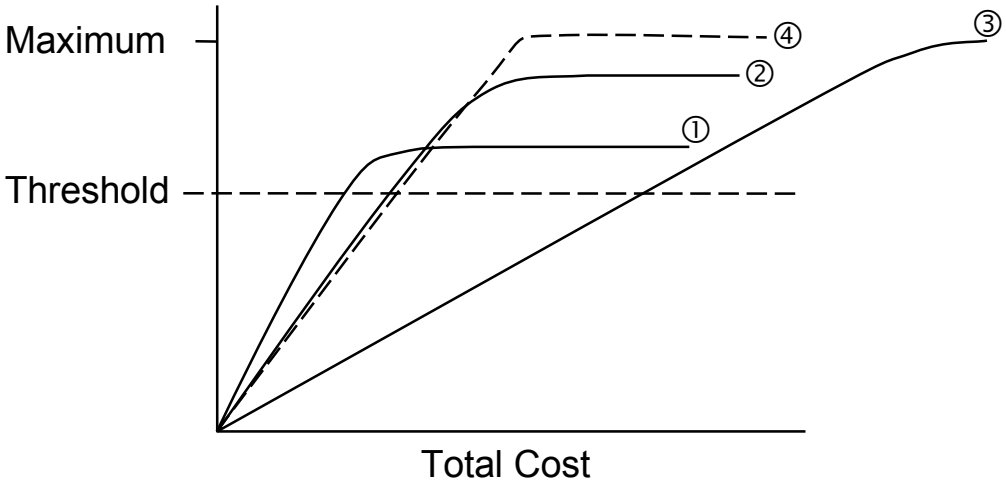
Cost As Independent Variable (CAIV) Is Not Only Dollars

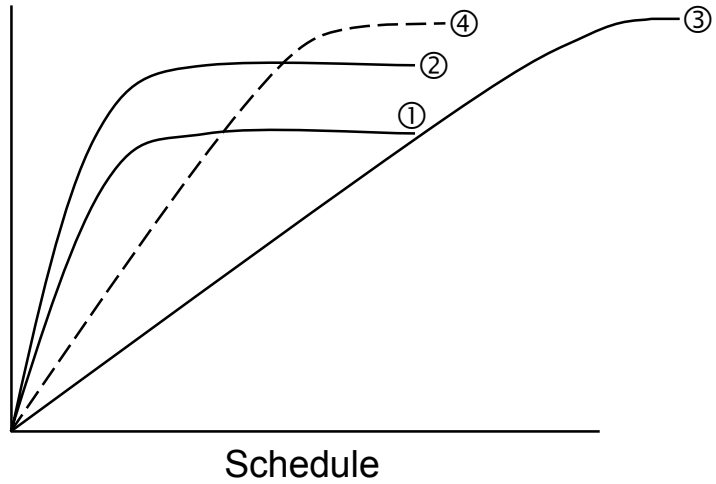
Cost =	Dollars	= CAIV
=	Weight	= WAIV
=	Reliability	= ReAIV
=	Schedule	= SAIV
=	Performance	= PAIV
=	Ruggedness	= RgAIV

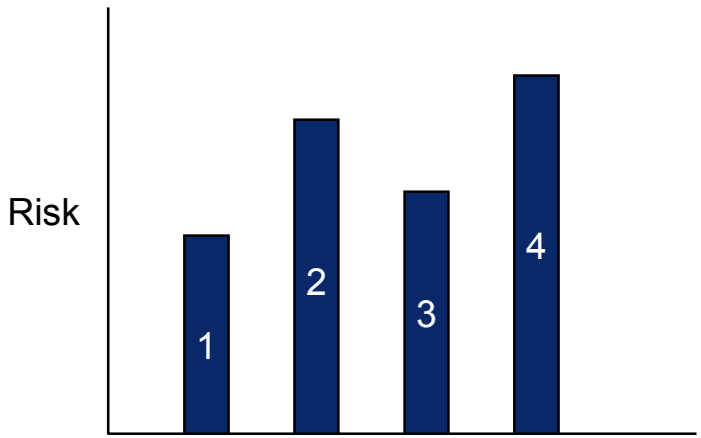
Use CAIV Process to Independently Address Variables and Drive Decisions

CAIV Alternative Example

Alternative Technologies



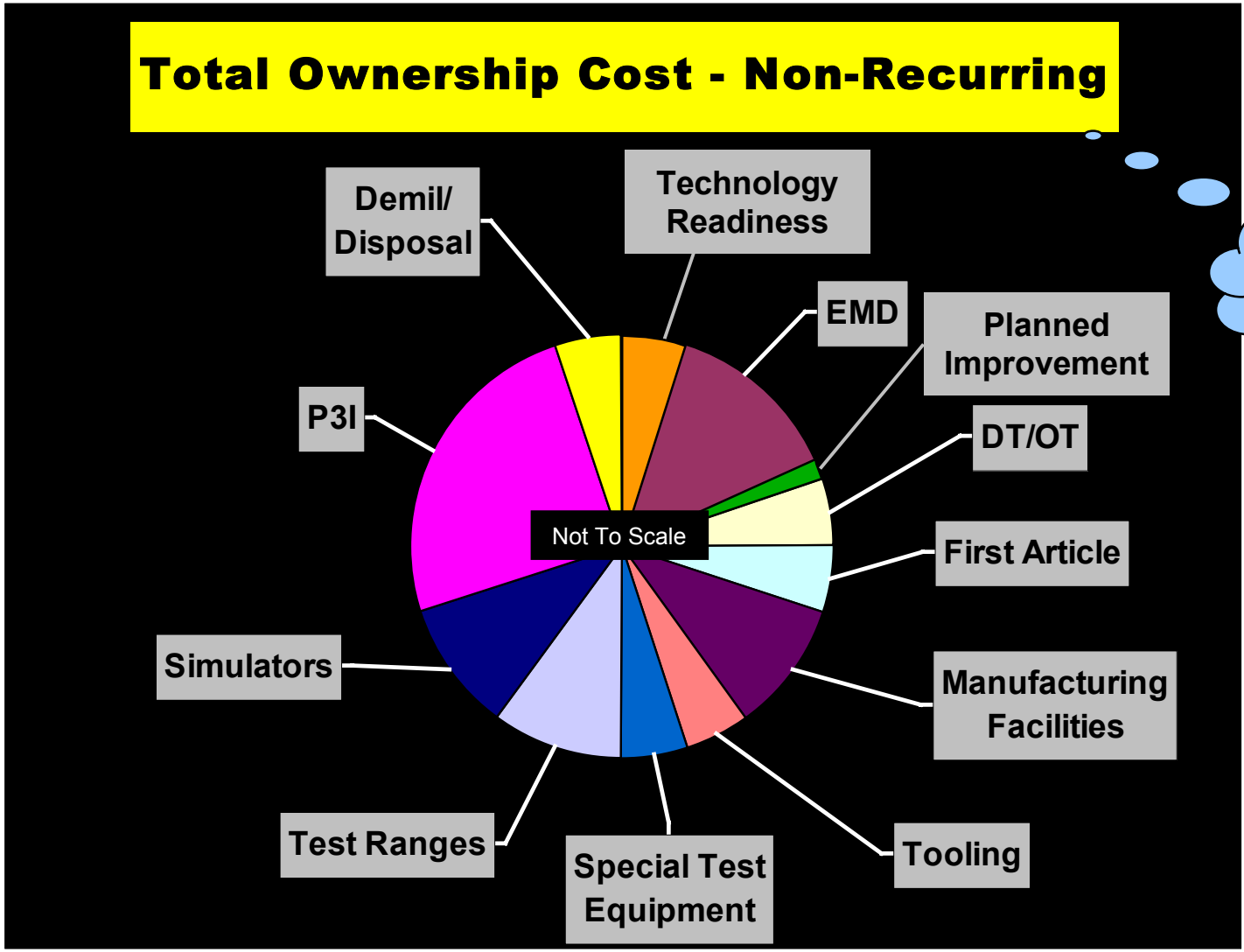




Decisions Based on Combined Rankings Ensure Benefits

ATK
ALLIANT TECHSYSTEMS

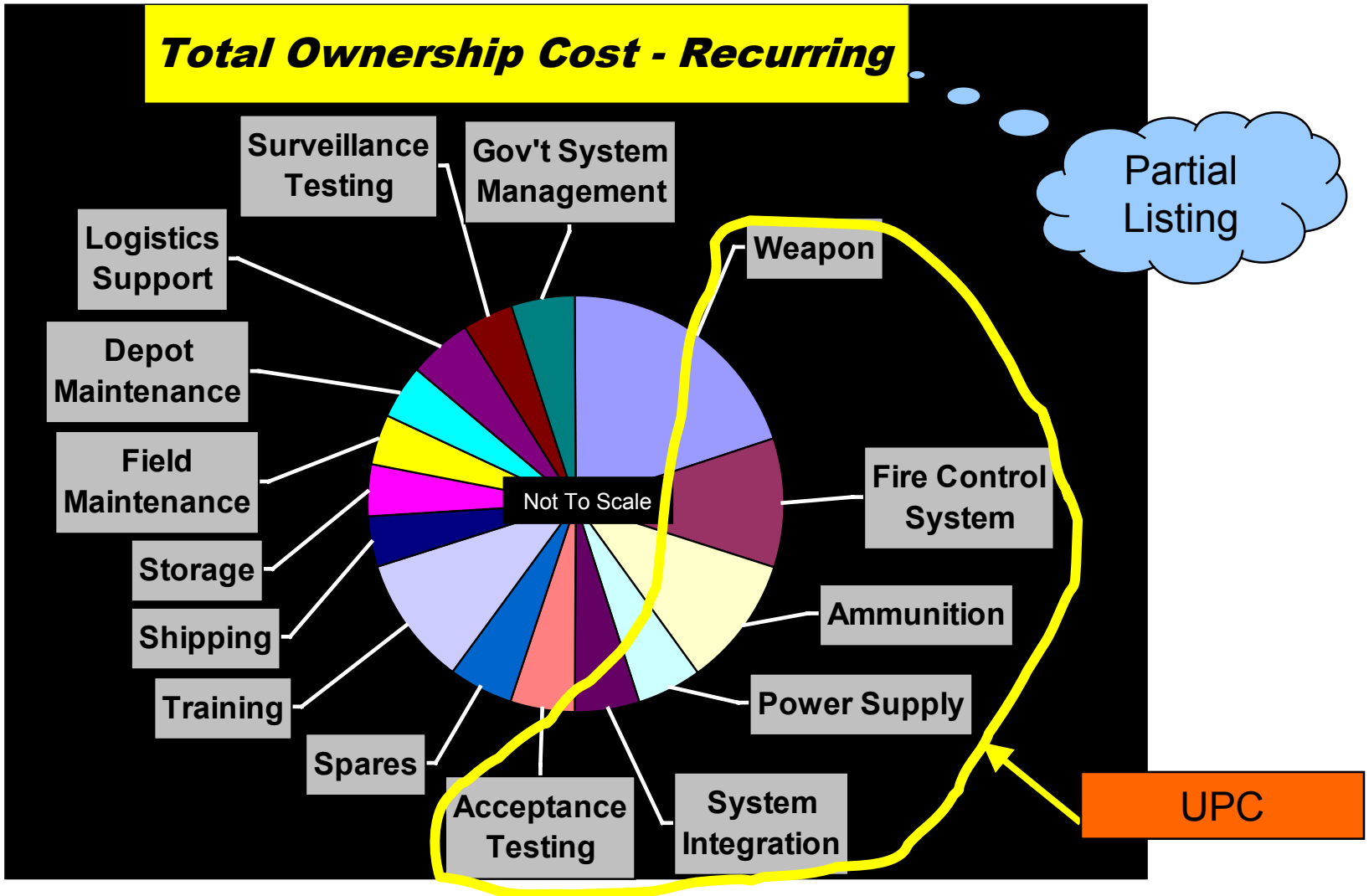
TOC – Non-Recurring Elements



Establishing and Tracking Costs Increases Fidelity

TOC – Recurring Elements

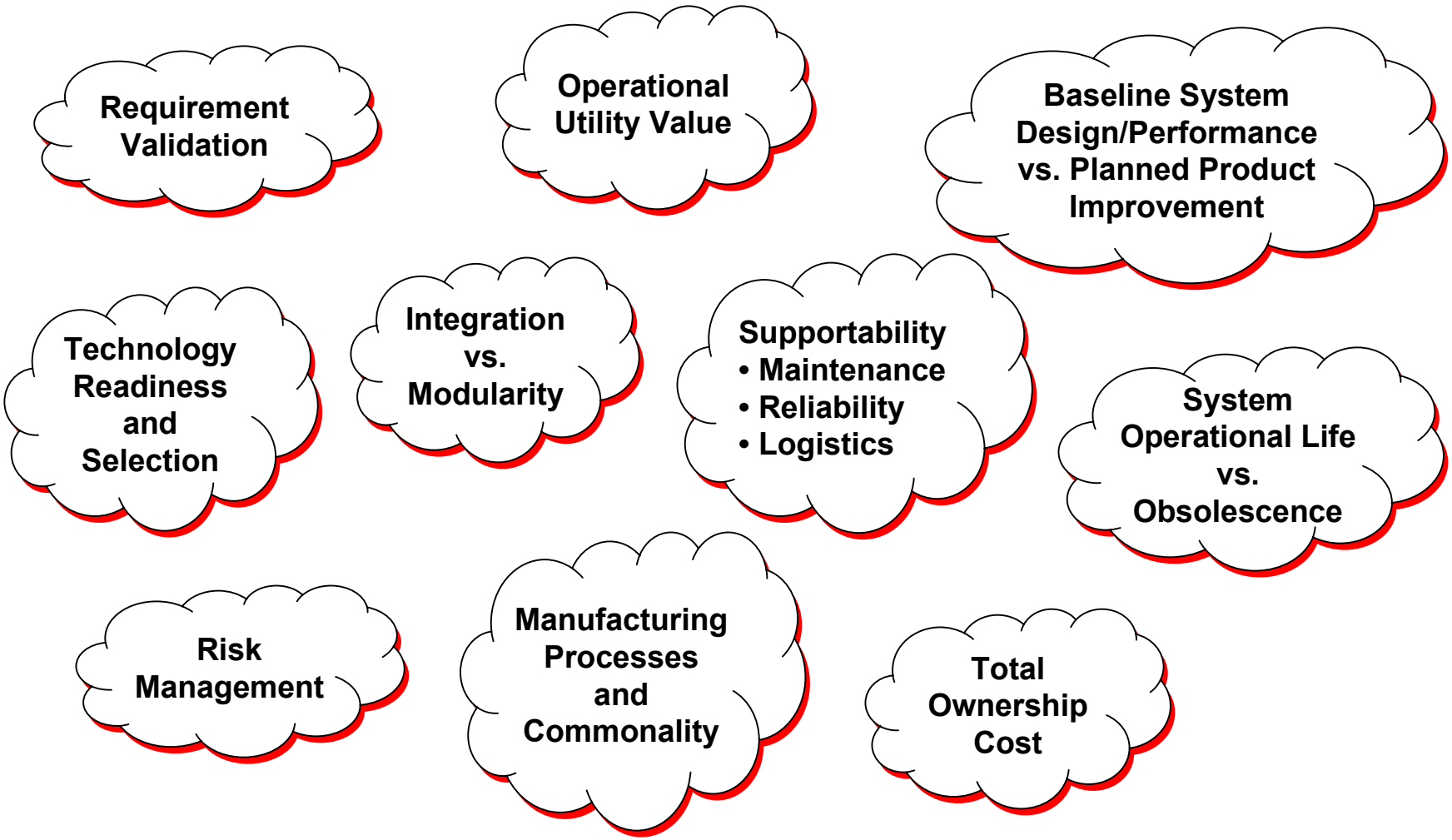
Small Arms
NDIA
2001



Select Critical Parameters — Assess Sensitivity

ATK
ALLIANT TECHSYSTEMS

CAIV Decision Applications



CAIV Payoffs

- Focuses system requirements to real operational value
- Establishes value for all design/performance decisions
  - Decision rationale clarity
- Rank technology readiness
  - Applies DoD technology readiness levels
  - Emerging, COTS, mature
- Supports path to rapid development and fielding
  - Confidence in incremental enhancements
- Central element of risk management
  - Risk level
  - Risk mitigation
- Directs payoff to appropriate topics

Individual and Crew Served Weapon Systems Enhancement Realized Effectively, Affordably, and Timely

CAIV Application

Total Ownership Cost (TOC) Management

Concept | **Proof of Principle** | **Development** | **Manufacturing** | **Deployment** | **Upgrade Insertion**

CAIV Process Throughout Life Cycle

Implement Early for Maximum Impact

Track Milestones and Roadmaps

Update Regularly

Timely Decisions With Solid Rationale

Conclusions

- Effective application of “Cost As Independent Variable (CAIV)” process offers benefits for entire program life cycle
- CAIV application is not complex
  - Requires rigorous:
    - Definition of metrics
    - Database development
    - Traceability
- CAIV links user objectives with affordability
  - Complements Quality Functional Deployment (QFD)

Small Arms System Evolution — Ensured Through CAIV Application

- **Performance**
- **Utility**
- **Affordability**